

# ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA MENGGUNAKAN *LOCAL EARTHQUAKE TOMOGRAPHY*

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NRP. 1113201014

Dosen Pembimbing

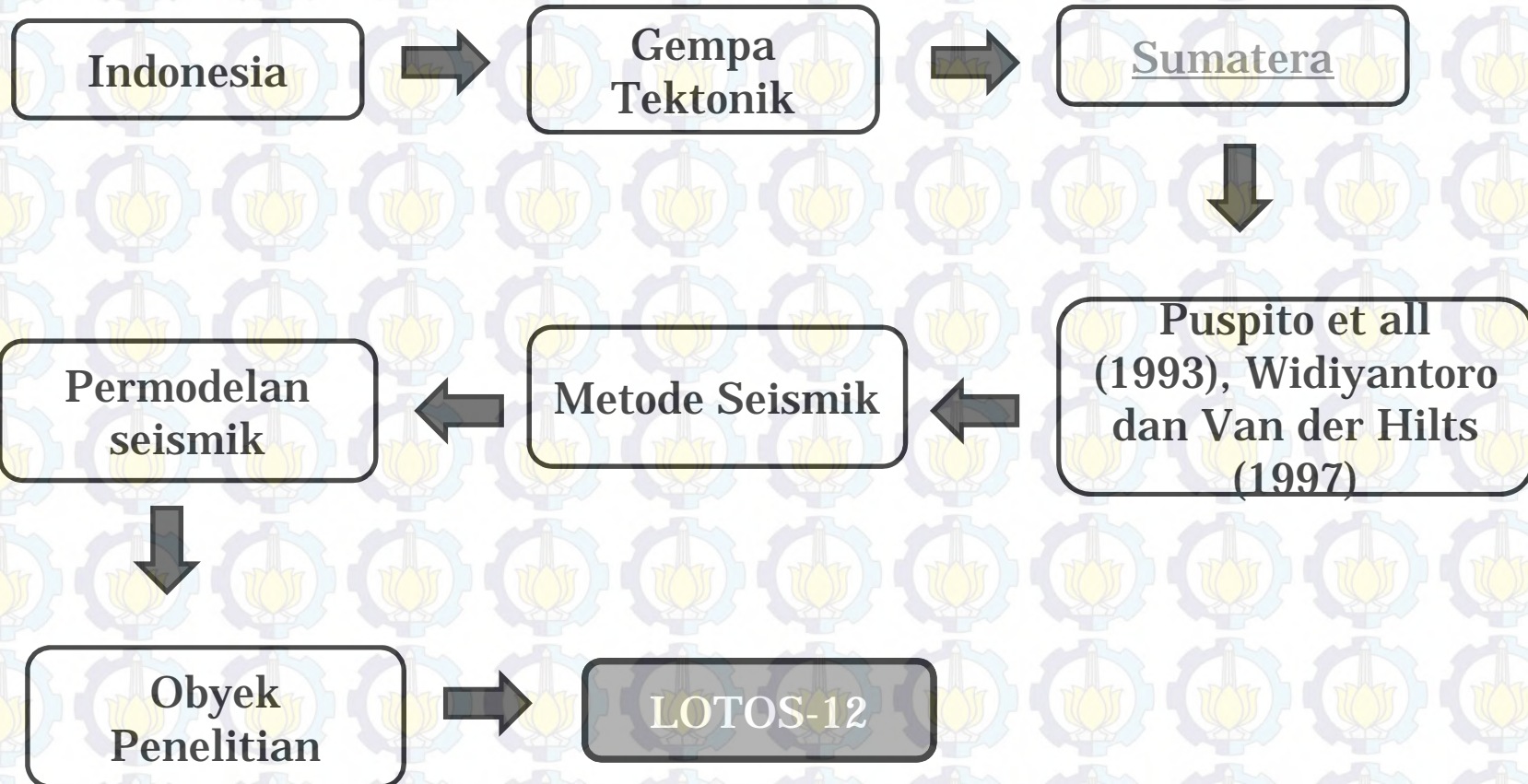
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Program Pascasarjana

***Jurusan Fisika***

Institut Teknologi Sepuluh Nopember  
2015

# Pendahuluan





# Pendahuluan



## Rumusan Masalah dan Tujuan

- Ø Waktu tiba gelombang-P ( $t_p$ ) dan waktu tiba gelombang-S ( $t_s$ ).
- Ø Distribusi anomali kecepatan gelombang-P dan kecepatan gelombang-S.
- Ø Tomografi 3D Pulau Sumatra menggunakan LOTOS-12.



## Batasan Masalah

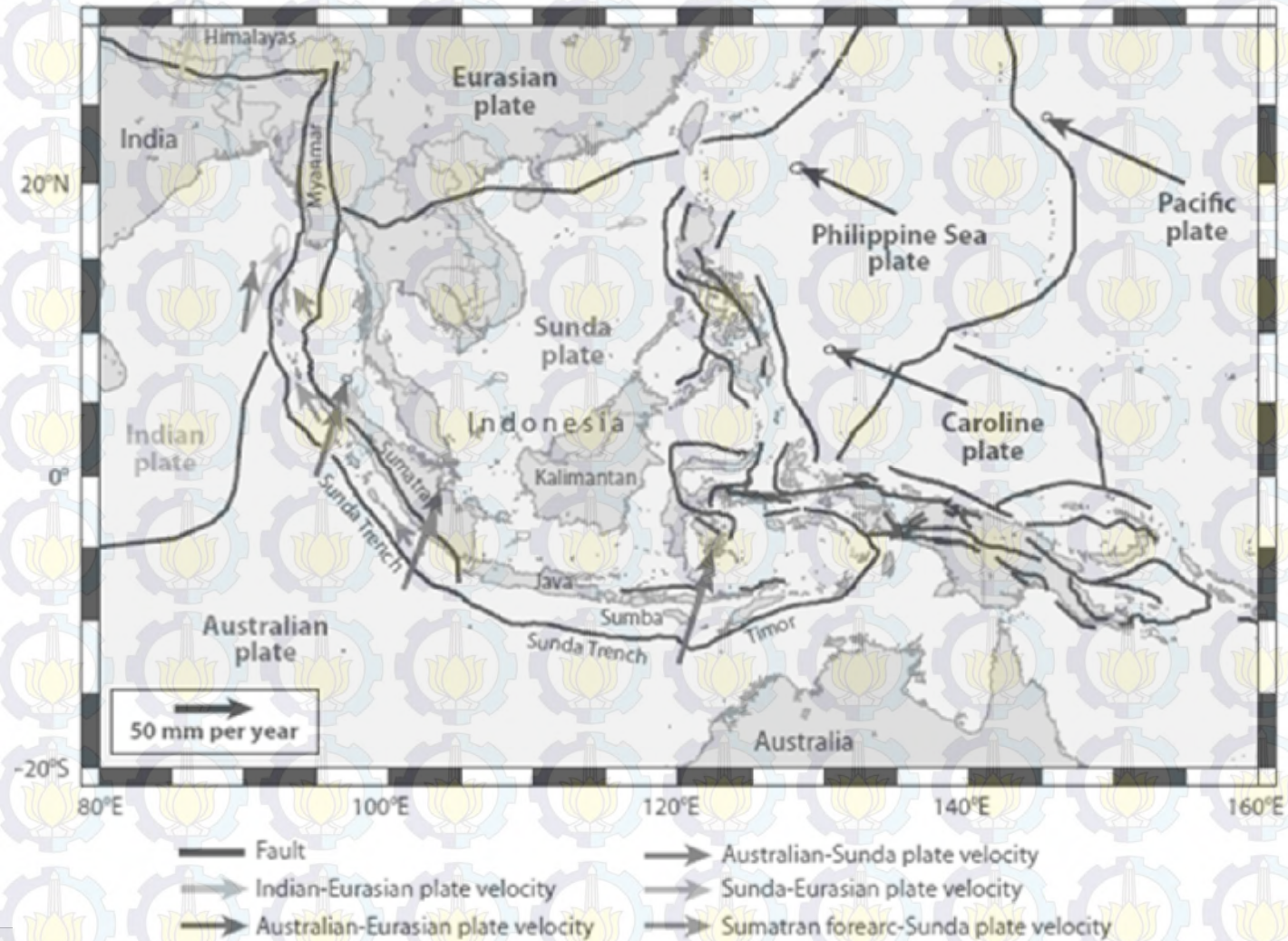
- Ø Data yang digunakan merupakan data gempa bumi di pulau Sumatera ( $6^{\circ}\text{LU}$ - $6^{\circ}\text{LU}$  dan  $95^{\circ}\text{BT}$ - $108^{\circ}\text{BT}$ ) pada tanggal 10 Maret 2013 sampai 10 Maret 2014.
- Ø Pengolahan data awal pada penentuan waktu tiba gelombang-P dan waktu tiba gelombang-S menggunakan *Seisgram2K60 Software*.
- Ø Proses inversi tomografi menggunakan LOTOS-12



# Kajian Pustaka



## Struktur Geologi Sumatera



ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN *LOCAL EARTHQUAKE TOMOGRAPHY*



# Kajian Pustaka

## Gelombang Seismik

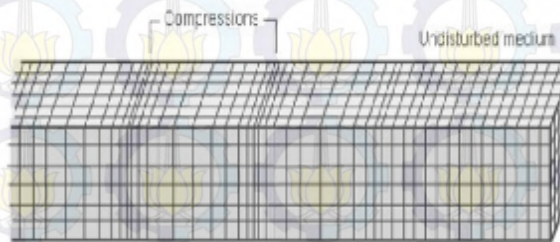
### *Gelombang Badan*

- Gelombang Primer
- Gelombang Sekunder

### *Gelombang Permukaan*

- Gelombang Rayleigh
- Gelombang Love

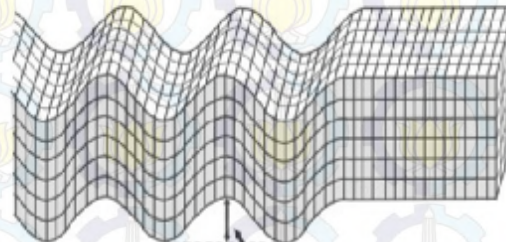
P Wave



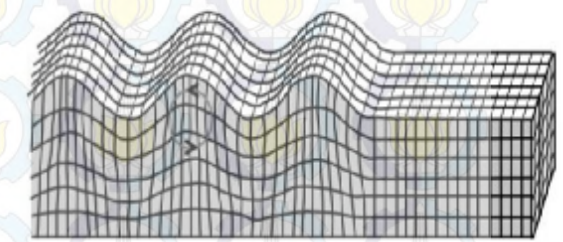
Love Wave



S Wave



Rayleigh Wave





# Kajian Pustaka

## Penentuan Hyposenter dengan Hypo71

Hiposenter: lokasi gempa (data latitude, data *longitude* dan data kedalaman bawah permukaan serta data waktu asal).

Ø Hypo71 : *file* .INP , *file* .PRT dan *file* .PUN

✓ Persamaan residual :  $r_e = t - t_0 - t^{cal}$

✓ Persamaan kuadrat terkecil :

✓ Linierisasi persamaan kuadrat terkecil

✓ Matriks persamaan residual:  $J\Delta m = \Delta d$   $r_e = \frac{\partial T_e}{\partial X_0} dx + \frac{\partial T_e}{\partial Y_0} dy + \frac{\partial T_e}{\partial Z_0} dz + dt$

(J: matriks Jacobian,  $\Delta m$ : hiposenter yang ingin diperbaiki  $\Delta d$ : parameter data)

✓ Hiposenter yang ingin diperbaiki

$$[J]^T [J] \Delta m = [J]^T \Delta d$$

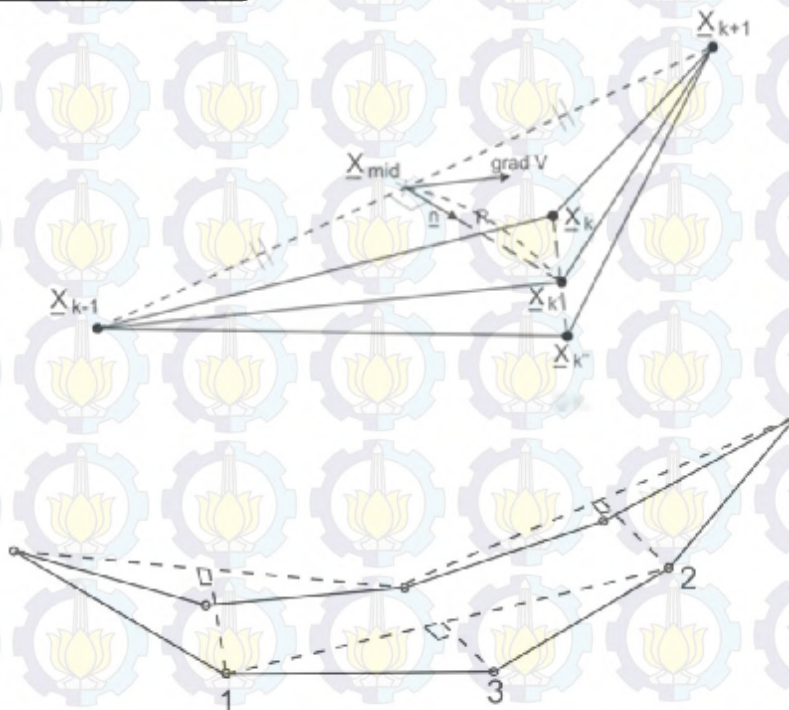
$$\Delta m = [J^T J]^{-1} J^T \Delta d$$



# Kajian Pustaka

## Inversi Tomografi LOTOS-12

### *Ray Tracing*



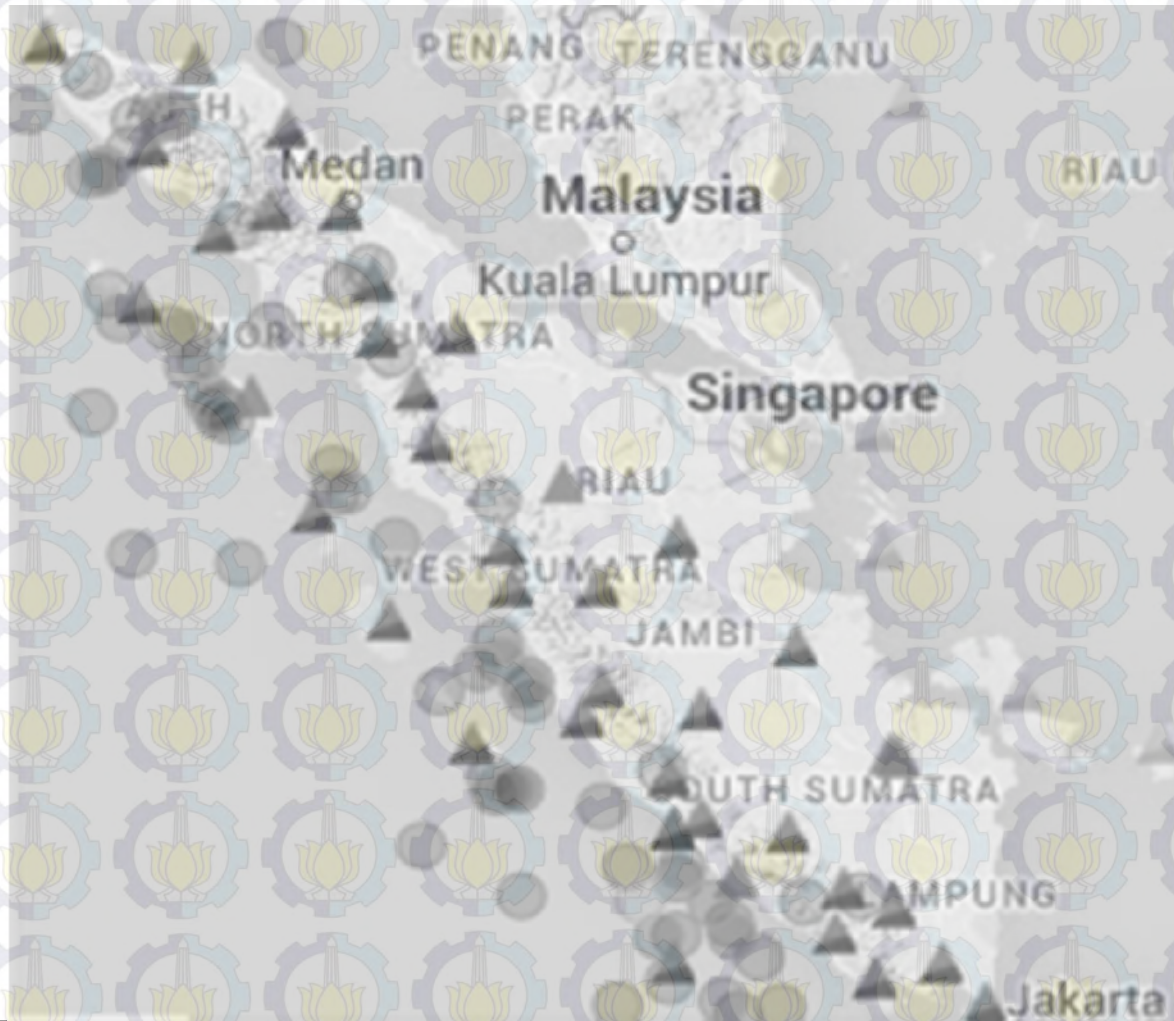
Kelebihan :

- Selain inversi untuk  $V_p$  dan  $V_s$ , LOTOS-12 juga memiliki kemampuan untuk menginversi  $V_p/V_s$
- Disediakan beberapa contoh berbeda yang dapat digunakan untuk merekonstruksi model baru
- Hasil dalam bidang horisontal dapat disajikan dalam tipe PNG *bitmap* tanpa menggunakan *software* grafis apapun

# Metodologi



## Area Penelitian



ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN *LOCAL EARTHQUAKE TOMOGRAPHY*



# Metodologi



## Data Penelitian

Data didownload dari  
[www.WebDc.eu](http://www.WebDc.eu)

Batas Wilayah :  
6°LU - 6°LU dan 95°BT - 108°BT

Rentang waktu :  
10 Maret 2013 - 10 Maret 2014

*Magnitude* :  $\geq 4,7$  SR

Stasiun perekam : 35 Stasiun

71 event  
2.482 gelombang seismik





## Metodologi



### Alat

- q Openssl-0.9.8k\_win64
- q Jrdseed
- q TauP-2.1.1
- q Seisgram2k60
- q Hypo71
- q ArcViewGis3.3
- q LOTOS-12



## Download data di katalog gempa [www.webDc.eu](http://www.webDc.eu)

The screenshot shows the webDc.eu website interface. On the left, the 'Event Information' section includes fields for 'Catalog Services' (set to 'User Supplied'), 'Catalog Service' (set to 'GFZ'), 'Date Interval' (from 2013-03-01 to 2014-03-01), 'Minimum Magnitude' (4.7), 'Depth from' (0 to 999 km), and 'Coordinates' (W 95, 130 E). Below these are 'Reset' and 'Append' buttons. On the right, a map of Southeast Asia is displayed, with a red dot indicating the location of the earthquakes in Northern Sumatra. Below the map, the 'Event and Station List' section shows a table of 71 events. The table has columns for 'Origin Time', 'Mag.', 'Type', 'Lat.', 'Long.', 'Depth', and 'Region'. The first four events are listed, all occurring in Northern Sumatra, Indonesia, with magnitudes ranging from 4.7 to 5.2.

Origin Time	Mag.	Type	Lat.	Long.	Depth	Region
2014-02-23T01:47:07	4.7		1.18	97.19	27.0	Northern Sumatra, Indonesia
2014-02-22T17:29:52	5.2		1.19	97.26	33.0	Northern Sumatra, Indonesia
2014-02-22T17:28:01	4.8		1.18	97.24	27.0	Northern Sumatra, Indonesia
2014-02-22T11:45:37	4.8		1.16	97.18	19.0	Northern Sumatra, Indonesia



Openssl (meng-*encrypt* data dari WebDC)  
Jrdseed (mengubah format \*seed - banyak *file* \*SAC)

```
Command Prompt - java -jar JrdseedVer0.10.1.jar
Microsoft Windows [Version 6.2.9200]
(c) 2012 Microsoft Corporation. All rights reserved.

C:\Users\SITI DIAH>d:
D:\>cd "DATA SUMATERA <TAMBAHAN>"
D:\DATA SUMATERA <TAMBAHAN>>cd 20140103_0820
D:\DATA SUMATERA <TAMBAHAN>\20140103_0820>rename 20140103_0820.seed 20140103_0820.seed.openssl
D:\DATA SUMATERA <TAMBAHAN>\20140103_0820>openssl des-cbc -pass pass:"EiePKxK#"
-in 20140103_0820.seed.openssl -out 20140103_0820.seed -d
D:\DATA SUMATERA <TAMBAHAN>\20140103_0820>java -jar JrdseedVer0.10.1.jar
<< Java SEED Reader, Release 0.10.1 237 >>
Input File </dev/nrst0> or 'Quit' to Exit: 20140103_0820.seed
Output File <stdout> :
Volume # [1-N] :
Options [acCsSpRtdel] : d
Station List <ALL> :
Channel List <ALL> :
Network List <ALL> :
Loc ids <ALL [ "-" for spaces ] :
Output Format [1-SAC, 2-AH, 3-CSS, 4-mini seed, 5-seed, 6-sac ascii, 7-SEG-Y] :
Select Data Type [E-Everything, D-Data of Undetermined State, R-Raw waveform D
ata, Q-QC'd data] :
Start Time<y> YYYY.DDD.HH:MM:SS.FFFF :
End Time<a> YYYY.DDD.HH:MM:SS.FFFF :
Extract Responses [Y/<N>] :
```



## TauP-2.1.1 (Perkiraan Tp dan Ts)

The TauP Toolkit

Time	Pierce	Path						
Dist	Dist (km)	Depth	Name	Time	Ray Par...	Purist Di...		
0.42	46.99	18.0	p	8.67	17.871	0.42	=	▲
0.42	46.99	18.0	P	8.93	17.053	0.42	=	
0.42	46.99	18.0	P	8.93	17.327	0.42	=	
0.42	46.99	18.0	s	14.96	30.853	0.42	=	
0.42	46.99	18.0	S	15.42	29.559	0.42	=	
0.42	46.99	18.0	S	15.42	29.910	0.42	=	
0.42	46.99	18.0	PcP	508.18	0.041	0.42	=	
0.42	46.99	18.0	ScS	930.22	0.075	0.42	=	
0.42	46.99	18.0	PKiKP	991.47	0.009	0.42	=	
0.42	46.99	18.0	SKiKS	1413.51	0.011	0.42	=	▼

Model iasp91 ▼ Distance (deg) 0.4226 Calculate

Phases Depth 18 Quit



## Picking Gelombang Seismik

## Prosedur

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Event	Stasiun	Origin	P (fix seis)	S (fix seis)	P (from taup)	S (from taup)	P-O (fromtaup)	S-O (from taup)	O.HYPO	O	P	S	P-O	S-O
2	64	GSI	2:19:30	02:19:40:543	02:19:47:984	02:19:38.93	02:19:45.42	12:00:09 AM	12:00:15 AM	02:19:30.54	1170.54	1180.543	1187.984	10.003	17.444





## Relokasi Hyposenter Hypo71

## Prosedur

HYPO71PC - Notepad

DATE	ORIGIN	LAT N	LONG E	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
140223	147 8.79	1-08.12	96-65.97	28.00		13	206131.4	.52	8.73	4.3	D1	
140222	1729 53.79	1-08.58	96-19.46									
140222	1728 2.17	1-12.19	96-52.74									
140222	1145 38.42	1-04.14	96-68.98									
140129	2139 40.28	4-29.69	100-38.45									
140120	445 15.85	4-56.67	102-52.16									
140111	2 9 06.64	0-40.10	97-28.58									
140103	1417 47.77	5-55.01	103-27.42									
140103	820 46.92	5-15.58	103-20.36									
131223	716 39.95	1-35.95	101-17.73									
131220	2110 47.80	4-14.97	96-13.16									
131210	427 20.66	3-35.16	103-14.01									
131206	1849 35.55	0-56.04	96-15.08									
131202	734 58.66	2- 4.38	96-38.46									
131201	936 23.67	4-21.25	102-19.93									
131201	630 00.06	2-04.42	96-51.46									
131128	16 2 51.10	0-09.27	98-33.28									
131119	2022 45.43	1-19.32	97-08.52									
131028	2327 46.33	5-04.16	102-57.22									
131022	540 39.94	5-02.90	95-43.76									
131019	147 26.35	4-40.11	95-05.42									
131015	1257 8.66	3-53.83	95-46.76									
131014	2356 28.81	1-49.93	101-23.32									
131013	1732 46.50	3-55.53	94-54.95									
131011	1312 57.32	5-56.92	103- 3.75									
131005	2129 37.71	3-21.61	100-37.41									
130928	18 8 22.48	4-15.50	101-43.27									
130926	20 9 32.90	1-36.63	96-54.44									
130918	1429 17.61	3-15.52	97-28.45									
130904	2332 39.46	2-28.36	96-02.44									
130904	911 58.83	2-51.53	98-54.87									
130828	543 27.35	2-03.66	100-40.08									
130825	4 0 4.49	1-08.01	95-51.41									
130824	12 4 20.93	3-08.64	102-15.24									

HYPO71PC - Notepad

EARTHQUAKE HYPOCENTER RELOCATION IN SUMATRA

\*\*\*\*\* PROGRAM: HYPO71PC (Version 1: 11/29/85) \*\*\*\*\*

TEST(1)	TEST(2)	TEST(3)	TEST(4)	TEST(5)	TEST(6)	TEST(7)	TEST(8)	TEST(9)	TEST(10)	TEST(11)	TEST(12)	TEST(13)	
STANDARD	1.000	10.0000	2.0000	.0500	5.0000	4.0000	-.8700	2.0000	.0035	100.0000	8.0000	.5000	1.0000
RESET TO	1.0000	100.0000	1.0000	.0100	30.0000	1.0000	-.8700	2.0000	.0035	300.0000	8.0000	.5000	1.0000

HYPO71PC - Notepad

EARTHQUAKE HYPOCENTER RELOCATION IN SUMATRA

HEAD  
RESET TEST(02)=100.  
RESET TEST(03)=1.  
RESET TEST(04)=0.01  
RESET TEST(05)=30.  
RESET TEST(06)=1.  
RESET TEST(10)=300.

STN	LAT	LONG	ELV	DELY
1 BKNI	019.35N	101.23E	0	.00
2 GSI	118.13N	9734.31E	0	.00
3 PMBI	254.09N	10441.57E	0	.00
4 BLSE	522.03N	10514.43E	0	.00
5 DSRI	028.45N	10434.40E	0	.00
6 EGSI	521.09N	10216.35E	0	.00
7 JMBI	140.35N	10334.34E	0	.00
8 KASI	531.25N	10429.45E	0	.00
9 KCSE	331.20N	9746.18E	0	.00
10 KRJI	2 5.28N	10127.43E	0	.00
11 KSI	339.06N	10235.34E	0	.00
12 LSI	427.26N	9758.13E	0	.00
13 LHSI	349.36N	10331.24E	0	.00
14 LNL	5 1.03N	104 3.32E	0	.00
15 MASI	3 8.29N	10214.23E	0	.00
16 MDSI	429.10N	10410.42E	0	.00
17 MKBI	226.51N	10114.22E	0	.00
18 MLSI	416.01N	9624.14E	0	.00
19 MNSI	047.44N	9934.47E	0	.00
20 PBSI	0 3.17N	9816.48E	0	.00
21 PDSI	054.42N	10027.42E	0	.00
22 PPSE	246.36N	10000.36E	0	.00

ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN LOCAL EARTHQUAKE TOMOGRAPHY



# Inversi Tomografi LOTOS-12

# Prosedur

rays - Notepad

File Edit Format View Help

97.11000

1.14000

28.00

25

1

20

25.535

2

20

45.333

1

30

23.419

2

30

42.667

1

9

35.164

2

9

64.683

1

33

29.965

2

33

63.095

1

23

34.744

2

23

61.319

1

28

46.366

2

28

83.430

1

18

47.160

2

18

83.654

1

12

49.609

2

12

89.064

1

21

57.076

2

21

99.076

1

1

53.192

2

1

102.68

1

22

65.563

2

22

126.22

1

10

74.724

2

10

140.27

1

17

75.797

97.11000

1.15000

35.20

36

1

30

30.278

2

30

49.364

1

23

32.713

2

23

59.980

stat\_ft - Notepad

File Edit Format View Help

101.03964

0.3254167

1.000000

BKNI

97.575400

1.303600

1.000000

GSI

104.69925

-2.902430

1.000000

PM3I

105.24521

-5.367548

1.000000

BLSI

104.58000

-0.4793000

1.000000

DSRI

102.27629

-5.352410

1.000000

EGSI

103.57600

-1.676400

1.000000

JM3I

104.49596

-5.523610

1.000000

KASI

97.771570

3.522185

1.000000

KCSI

101.46193

-2.091199

1.000000

KR3I

102.59290

-3.651700

1.000000

KSI

97.970370

4.457251

1.000000

LASI

103.52333

-3.826624

1.000000

LHSI

104.05091

-5.017472

1.000000

LWSI

102.23961

-3.141521

1.000000

MASI

104.17823

-4.486037

1.000000

MDSI

101.23958

-2.447400

1.000000

MK3I

96.403980

4.266851

1.000000

MLSI

99.579630

0.7954980

1.000000

MWSI

98.280000

-0.0547000

1.000000

PBSI

100.46170

-0.9118000

1.000000

PDSI

100.01000

-2.776600

1.000000

PPSI

98.924000

2.695200

1.000000

PSI

102.33380

-0.3491000

1.000000

RGRI

99.832500

2.072300

1.000000

RPSI

99.431000

1.398800

1.000000

SBSI

101.42800

-0.9325000

1.000000

SDSI

99.009500

-1.326500

1.000000

SISI

102.59270

-2.392400

1.000000

SLSI

96.326700

2.408900

1.000000

SN3I

MAJOR\_PARAM - Notepad

File Edit Format View Help

\*\*\*\*\*

GENERAL INFORMATION :

1

KEY 1: REAL; KEY 2: SYNTHETIC

1

KEY 1: Vp and Vs; KEY 2: Vp and Vp/Vs

0

KEY 0: all data, KEY 1: odd events, KEY 2: even events

1

Ref. model optimization (0=no; 1=yes)

1

1: geogr, 2: Cartesian

0

1: true locations exist in separate line

2

1: calculations in a flat model, 2: spherical velocity

\*\*\*\*\*

AREA\_CENTER :

100.9919 -0.7283813

Center of conversion to XY

\*\*\*\*\*

1D LOCATION KEY :

1

1: using reference table (large areas);

2: using straight lines (small areas with high relief)

\*\*\*\*\*

ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN LOCAL EARTHQUAKE TOMOGRAPHY



## Inversi Tomografi LOTOS-12

## Prosedur

The image displays four Notepad windows showing the configuration files for the LOTOS-12 software. The windows are titled 'ref\_start - Notepad', 'config - Notepad', 'sethor - Notepad', and 'setver - Notepad'.

**ref\_start - Notepad** contains a table with the following data:

	Ratio vp/vs
0.000	2.31
1.000	4.27
2.000	5.52
5.000	6.23
16.000	6.41
33.000	6.70
40.000	7.80
100.000	8.00
225.000	8.40

**config - Notepad** contains the following configuration parameters:

```
***** MAP VIEW *****
500 800          size in pixels for horizontal section
1 1             ticks on axes for horizontal sections
***** VERTICAL SECTION *****
500 600          size in pixels for vertical section
25 35           ticks on axes for vertical sections
***** PLOTS WITH 1D VELOCITIES *****
500 800          size in pixels for the 1D models
2 10            Limits of P and S velocity distribution
-175 0           Depth limit
0.5 25           ticks on axes for 1D velocity plot
***** SCALES *****
blue_red.scl     scale for velocity anomalies
-10 10           diapason for velocity anomalies, %
blue_brown.scl   scale for Vp/Vs
1.4 1.99         diapason for Vp/Vs
rainbow_small.scl scale for absolute Vp
3.0 8.5          diapason for absolute Vp
rainbow_small.scl scale for absolute Vp
1.5 5.5
```

**sethor - Notepad** contains the following configuration parameters:

```
10              Number of sections
10 20 40 60 80 100 120 140 160 180 200      Depths of sections
-3 3 0.1 -4.0 4.0 0.1 f11, f12, df1, tet1, tet2, dtet
10             distance from nearest node
0              Smoothing factor1
0              Number of summary
0              index for source visualization
```

**setver - Notepad** contains the following configuration parameters:

```
3              Number of different sections
100.55512000, 1.1446200
101.82175000, -6.7515800
99.369350000, -0.17591000
103.95076000, -6.0508900
101.76785000, -0.01421000
99.531040000, -5.1615600
10           distance from section for visualization of events
3            dx
0 180 3       zmin,zmax,dz
50           Marks for indication of position of section
8           Distance to the nearest node
0           Smoothing factor
1           If 0, no sources are visualized
2 1          horizontal section and PS to show the location of profiles
0.10 0.10    dfi, dtet: shift fo
```



## Diagram Alir Penelitian

Studi Pustaka

Pengumpulan Data

*Picking* Data Seismogram

Relokasi Hiposenter

Inversi Tomografi

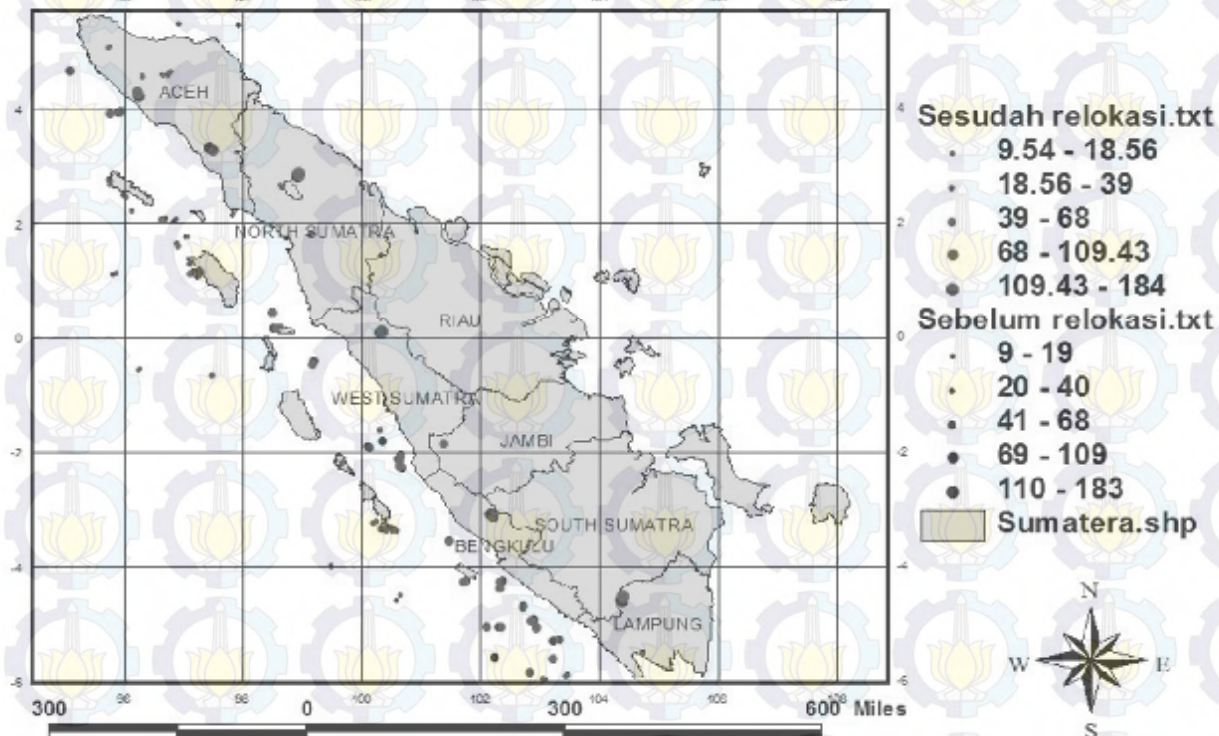
Model Kecepatan Anomali  
Gelombang P dan S dalam 3D

Analisis dan Interpretasi

# Hasil dan Pembahasan

## Posisi gempa sebelum dan sesudah relokasi

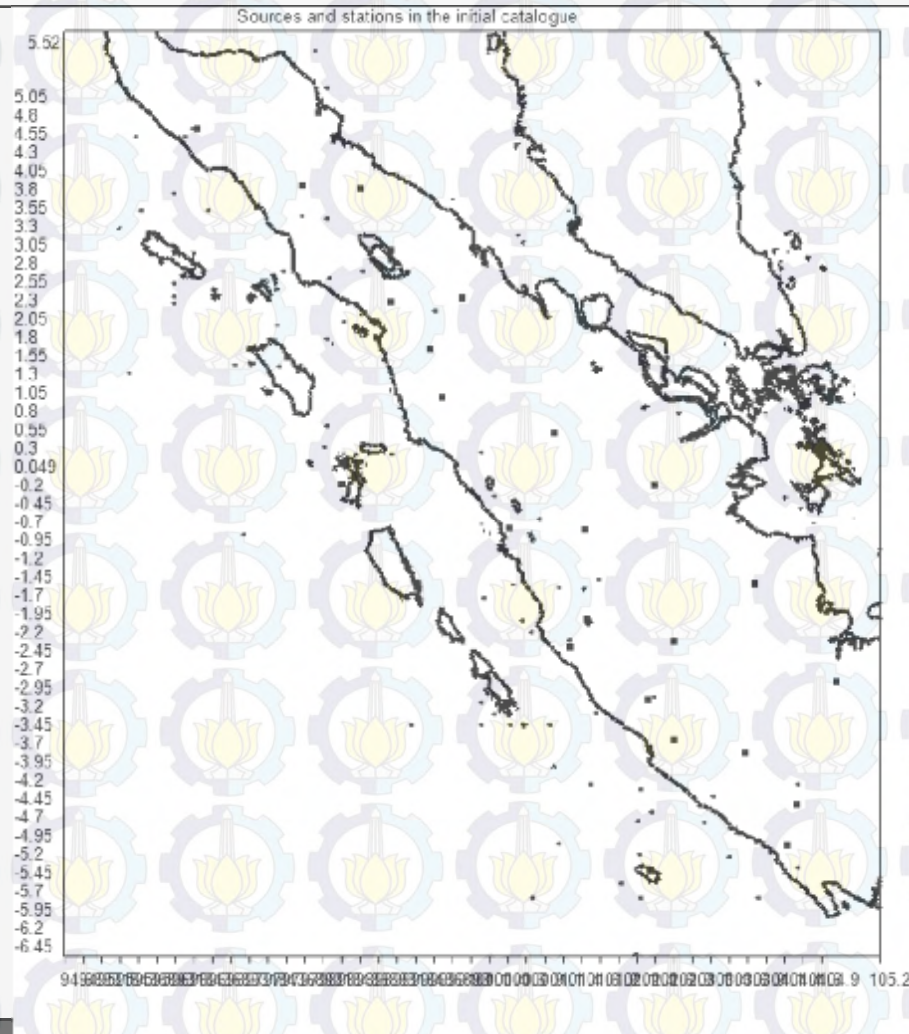
### Peta Relokasi Gempa Pulau Sumatera Periode 2013-2014





## Hasil dan Pembahasan

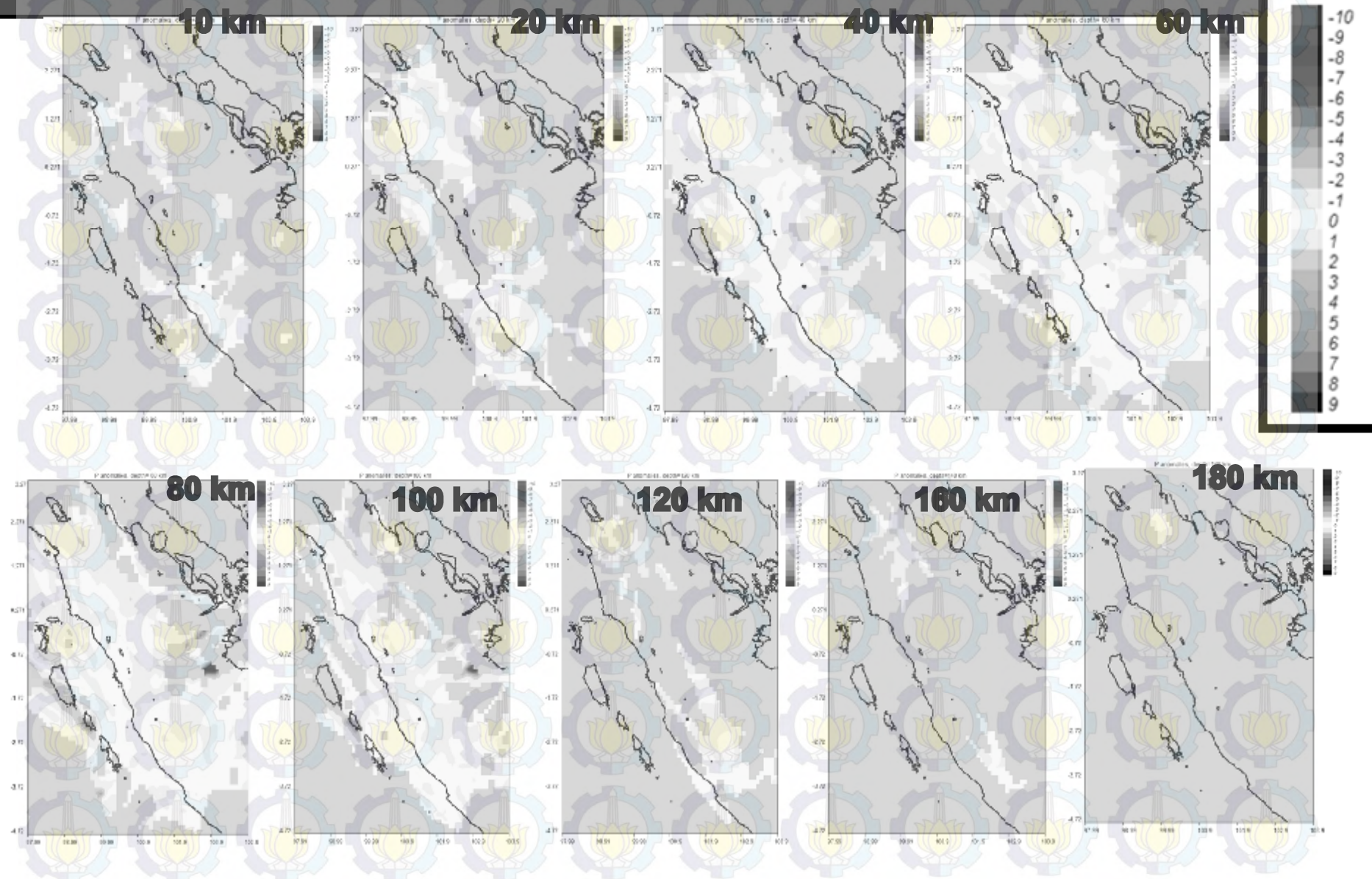
### Persebaran *event* gempa dan stasiun dengan code LOTOS



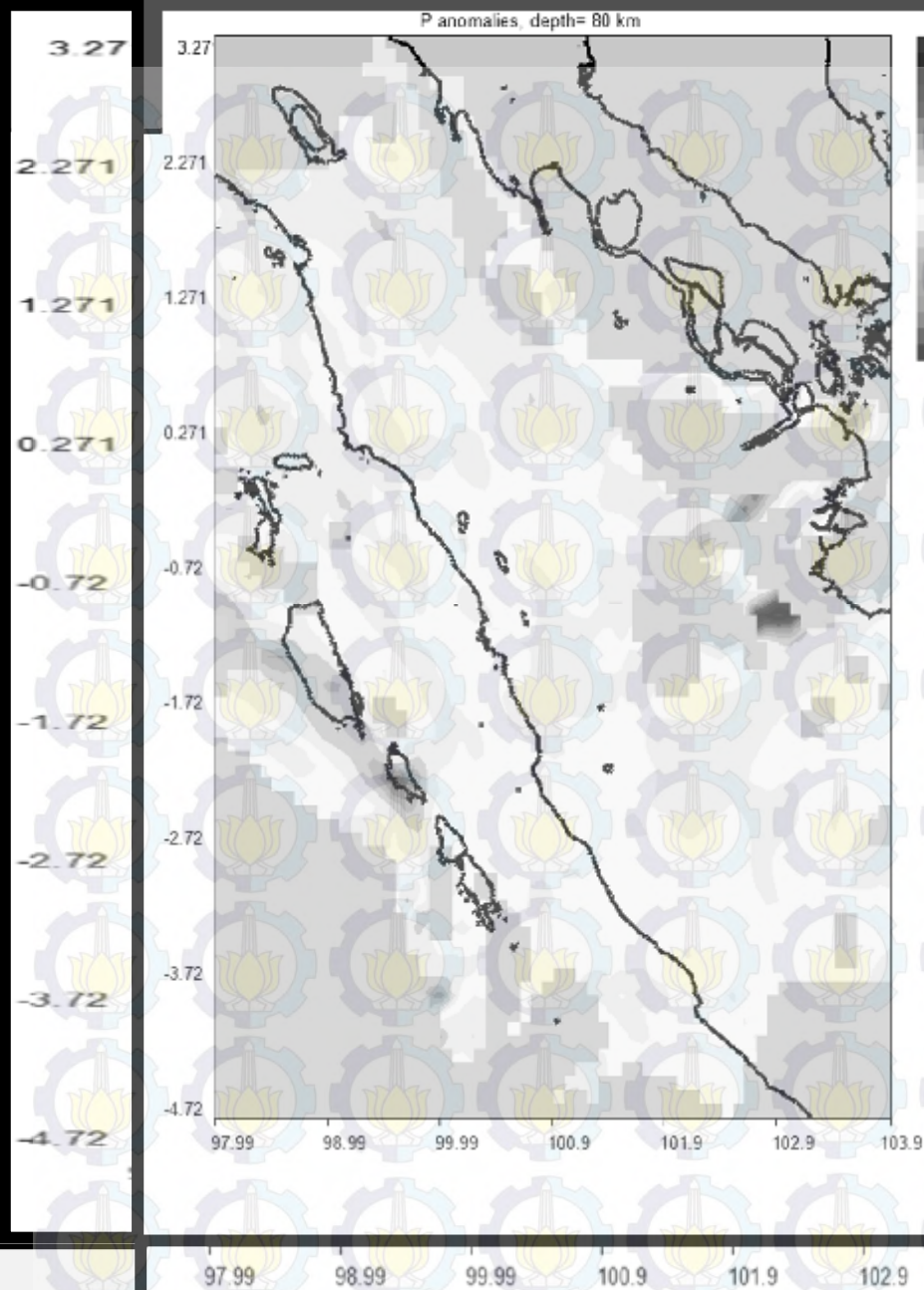
ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGGUNAKAN *LOCAL EARTHQUAKE TOMOGRAPHY*



## Distribusi anomali Vp sayatan horizontal

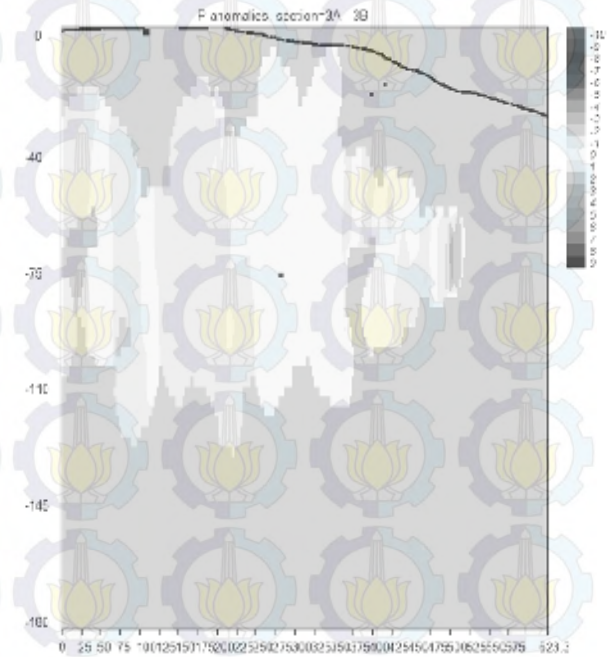
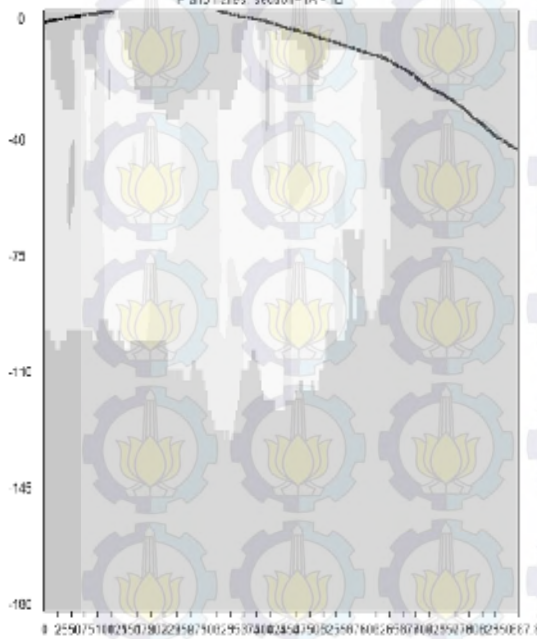
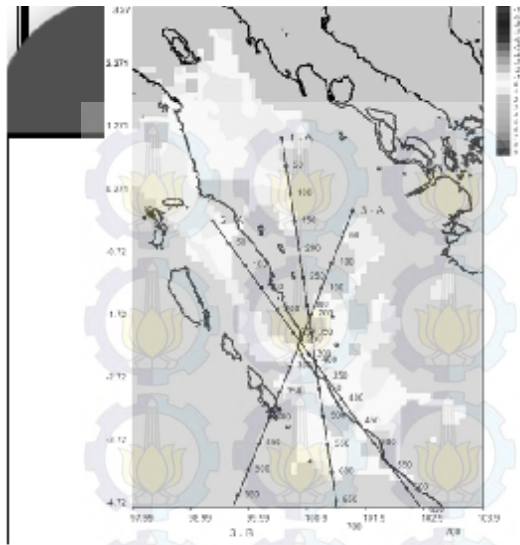






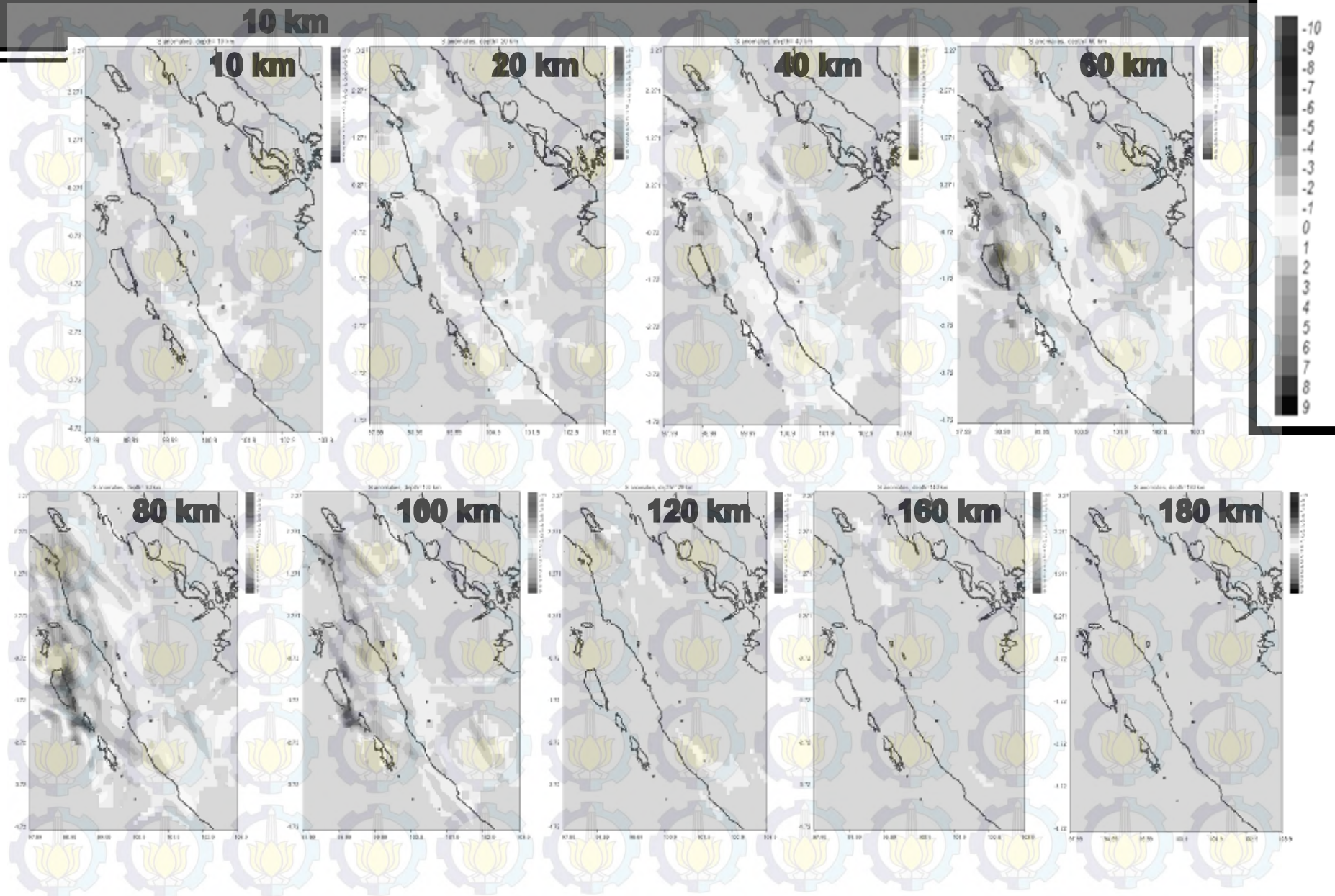


## Cross Section dan Anomali Vp sayatan vertikal

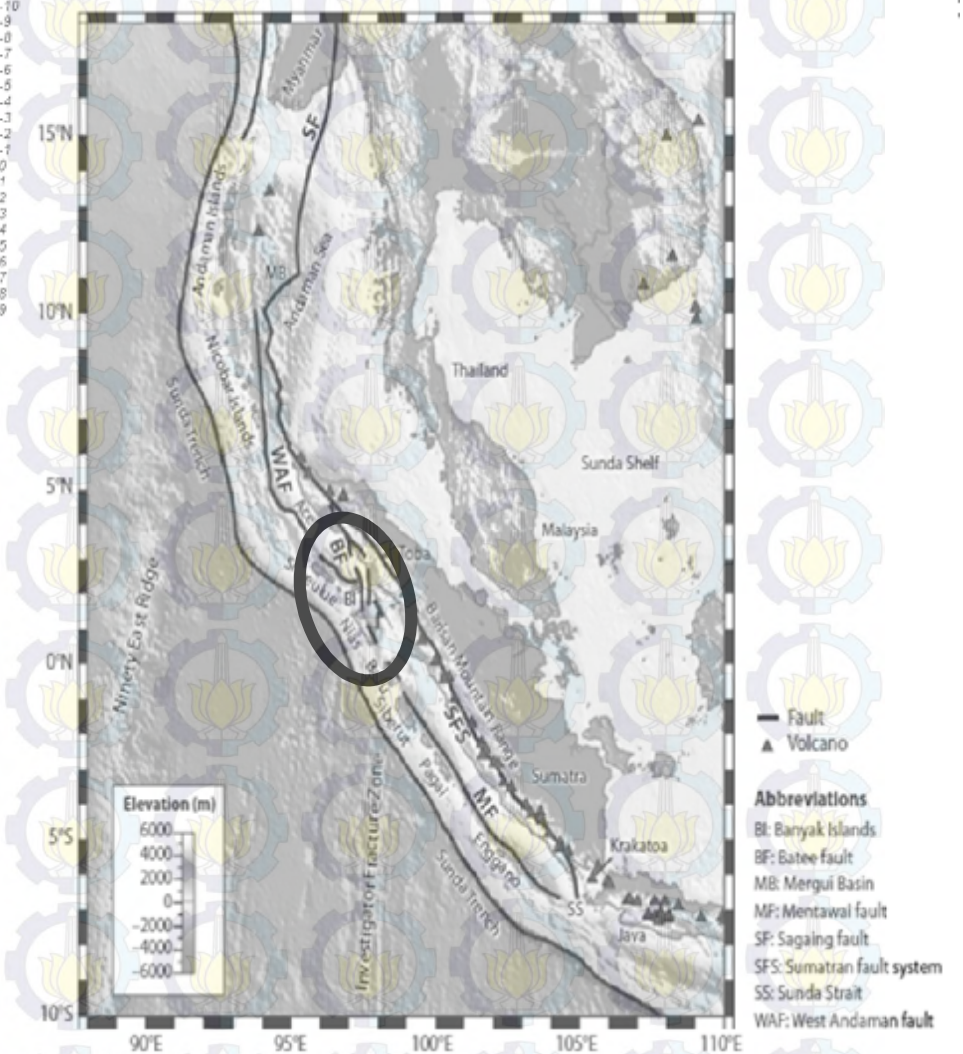
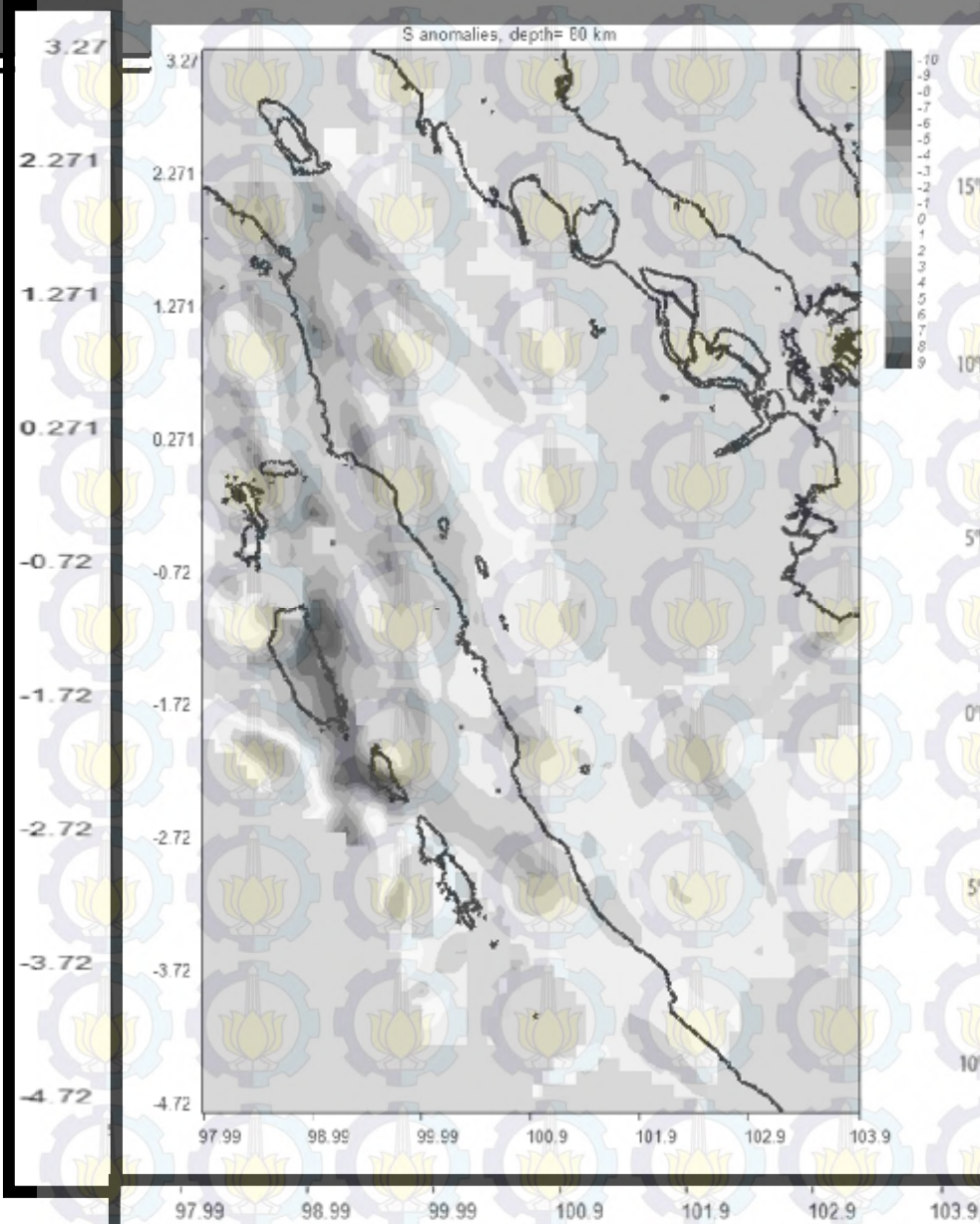




## Distribusi anomali Vs pada horizontal

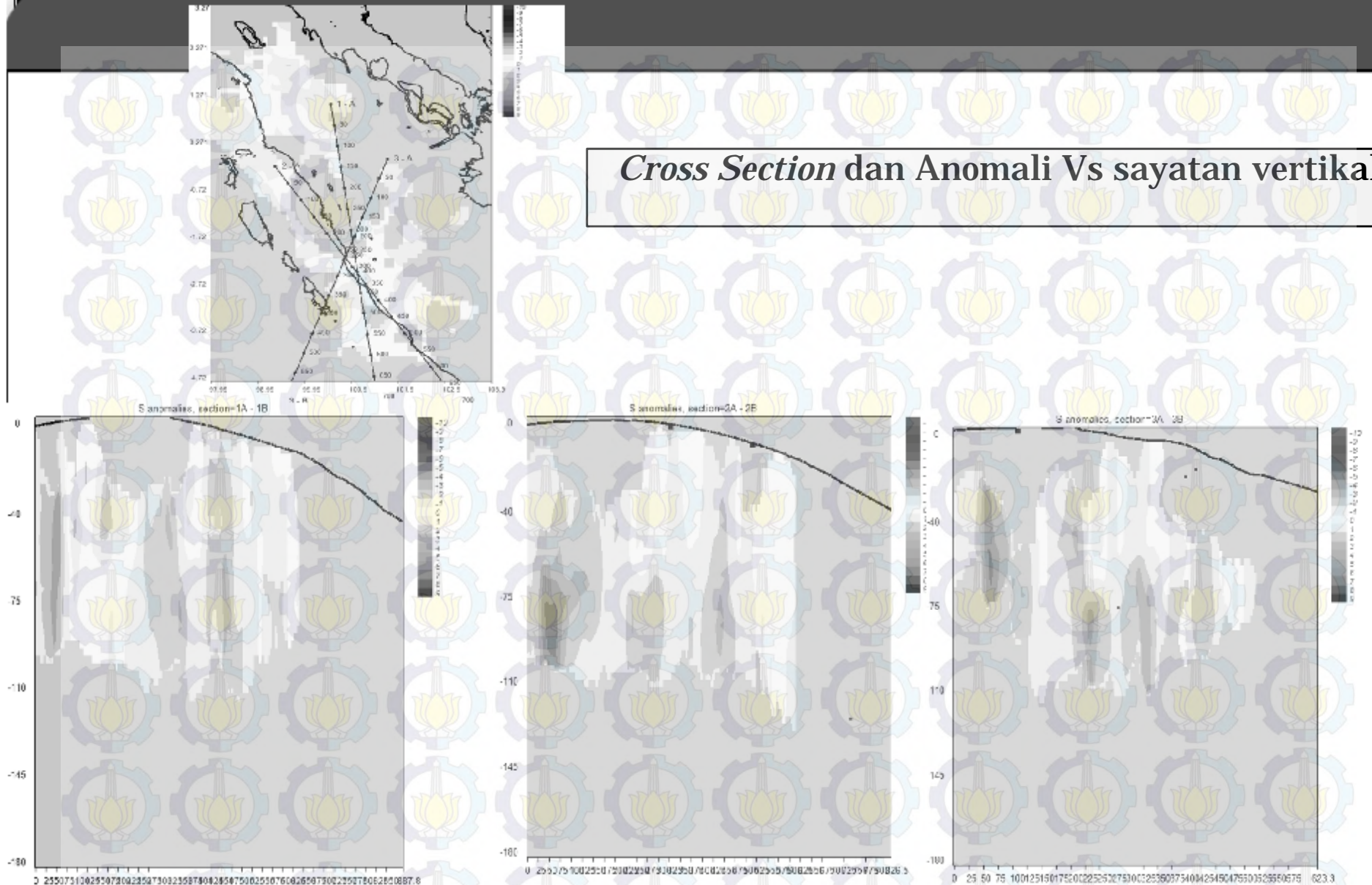






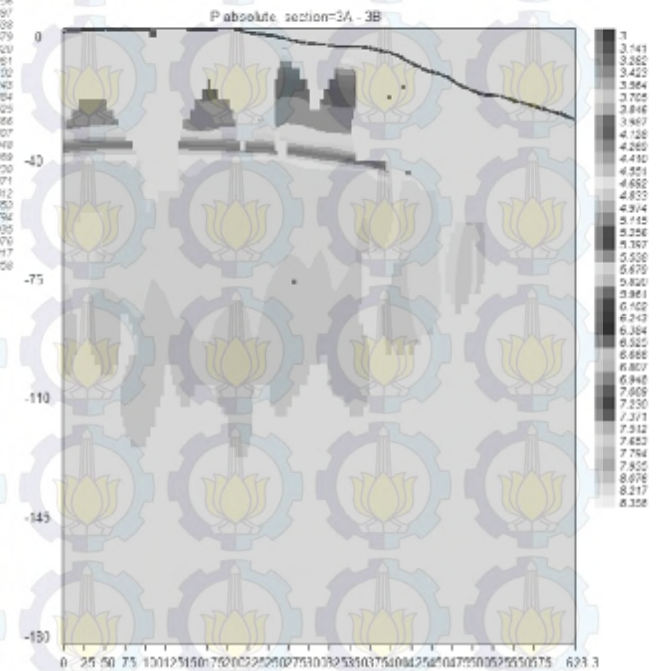
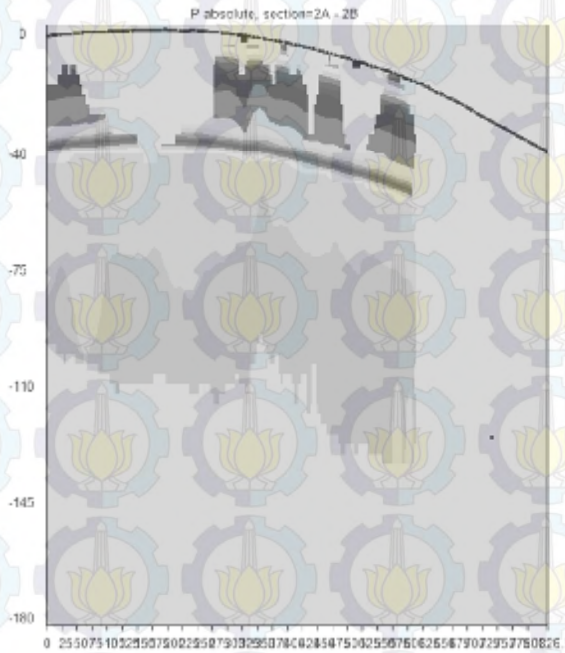
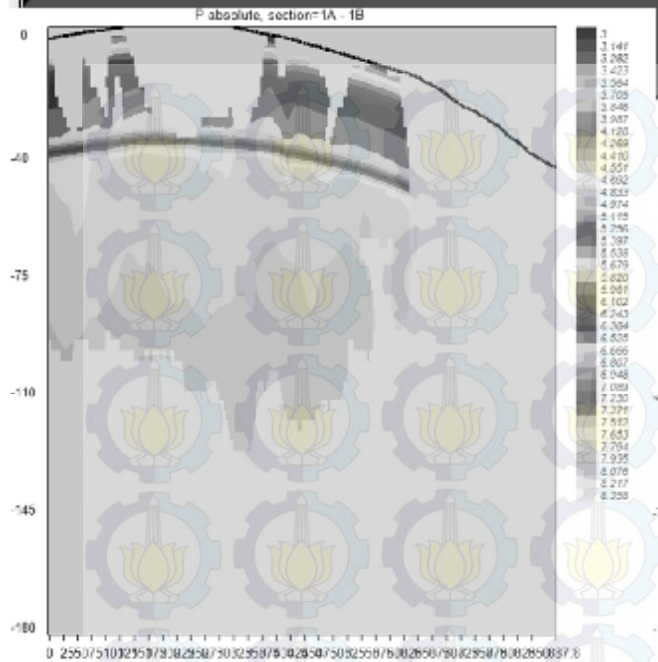


## Cross Section dan Anomali Vs sayatan vertikal





# Anomali Vp absolut sayatan vertikal





# Anomali Vs absolut sayatan vertikal



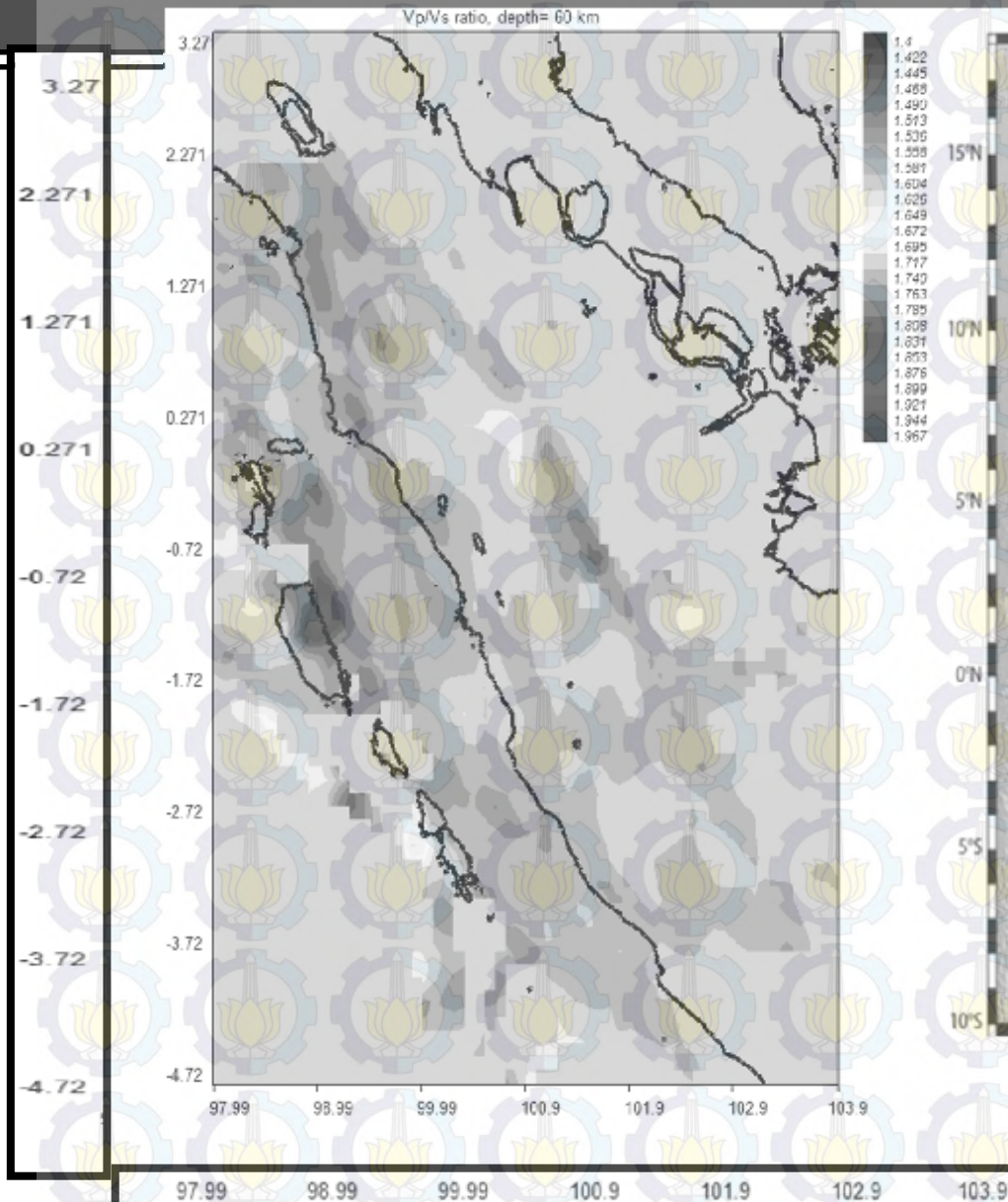
ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN *LOCAL EARTHQUAKE TOMOGRAPHY*



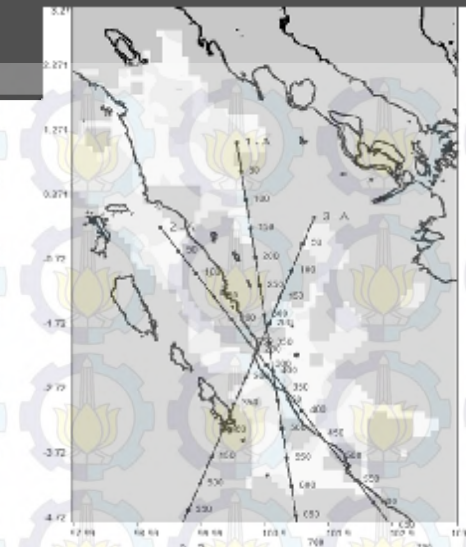
## Distribusi anomali $V_p/V_s$ pada horizontal



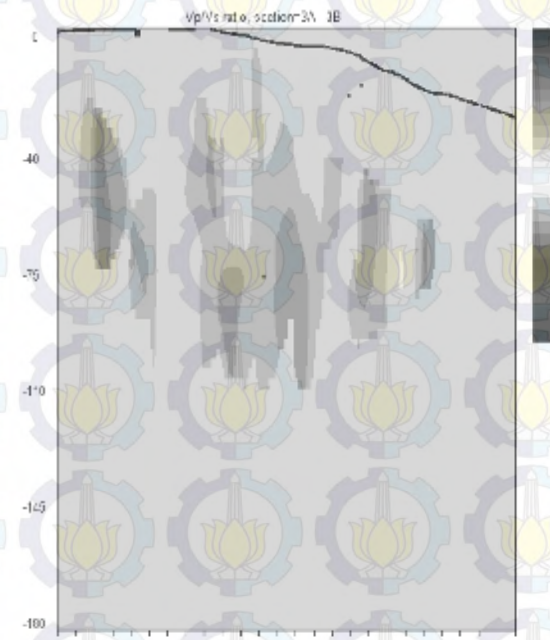
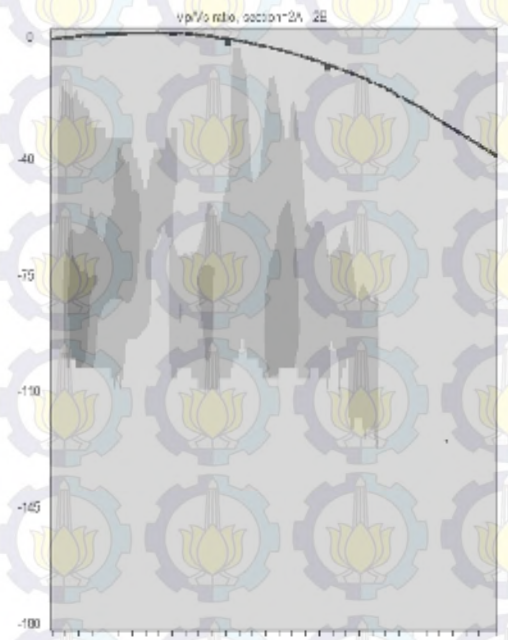
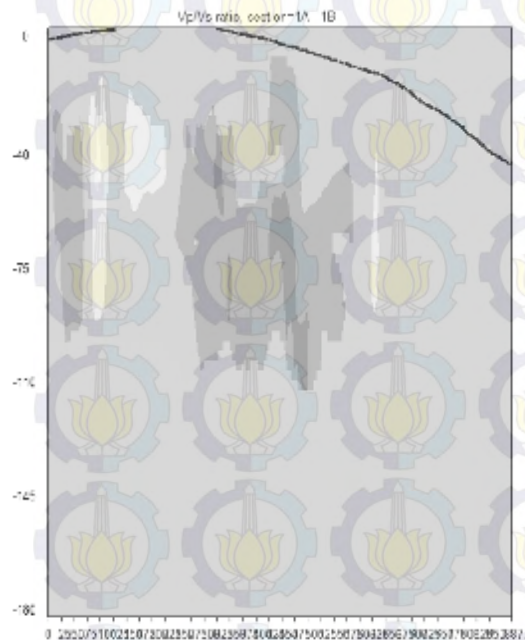








## Cross Section dan Anomali Vp/Vs sayatan vertikal



ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN *LOCAL EARTHQUAKE TOMOGRAPHY*



## Kesimpulan

ü 50 *event*: P-waves=621 S-waves=578; koordinat 95.09 hingga 104.39 dan -5.96 hingga 5.48 di kedalaman 9.54 km hingga 184 km.

ü Kerak atas:  $V_p=6.525$  km/s,  $V_s=4.064$  km/s; Kerak bawah:  $V_p=7.230$  km/s,  $V_s=4.269$  km/s; Mantel atas:  $V_p=7.935$  km/s,  $V_s=4.679$  km/s.

ü Rasio  $V_p/V_s$  Minimum=1.695 dan Maksimum=1.899.

ü Bidang Vertikal rasio  $V_p/V_s$  rendah diperoleh mayoritas di kedalaman sekitar 0-55 km, sedangkan rasio  $V_p/V_s$  tinggi di kedalaman 55 km-110 km.

ü Anomali negatif di daerah kepulauan Mentawai dan Nias, dikarenakan pada daerah tersebut terdapat beberapa jenis patahan: patahan Andaman, patahan Batee dan patahan Mentawai.





## Saran

Perlu adanya penambahan jumlah data gempa yang mempunyai distribusi sinar yang merata untuk mendapatkan citra tomografi yang lebih real dan dilakukan pengujian dengan data sintesis.







ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN *LOCAL TOMOGRAPHY*

**TERIMA KASIH**



ANALISIS TOMOGRAFI 3D PADA GEMPA BUMI DI SUMATERA  
MENGUNAKAN *LOCAL EARTHQUAKE TOMOGRAPHY*





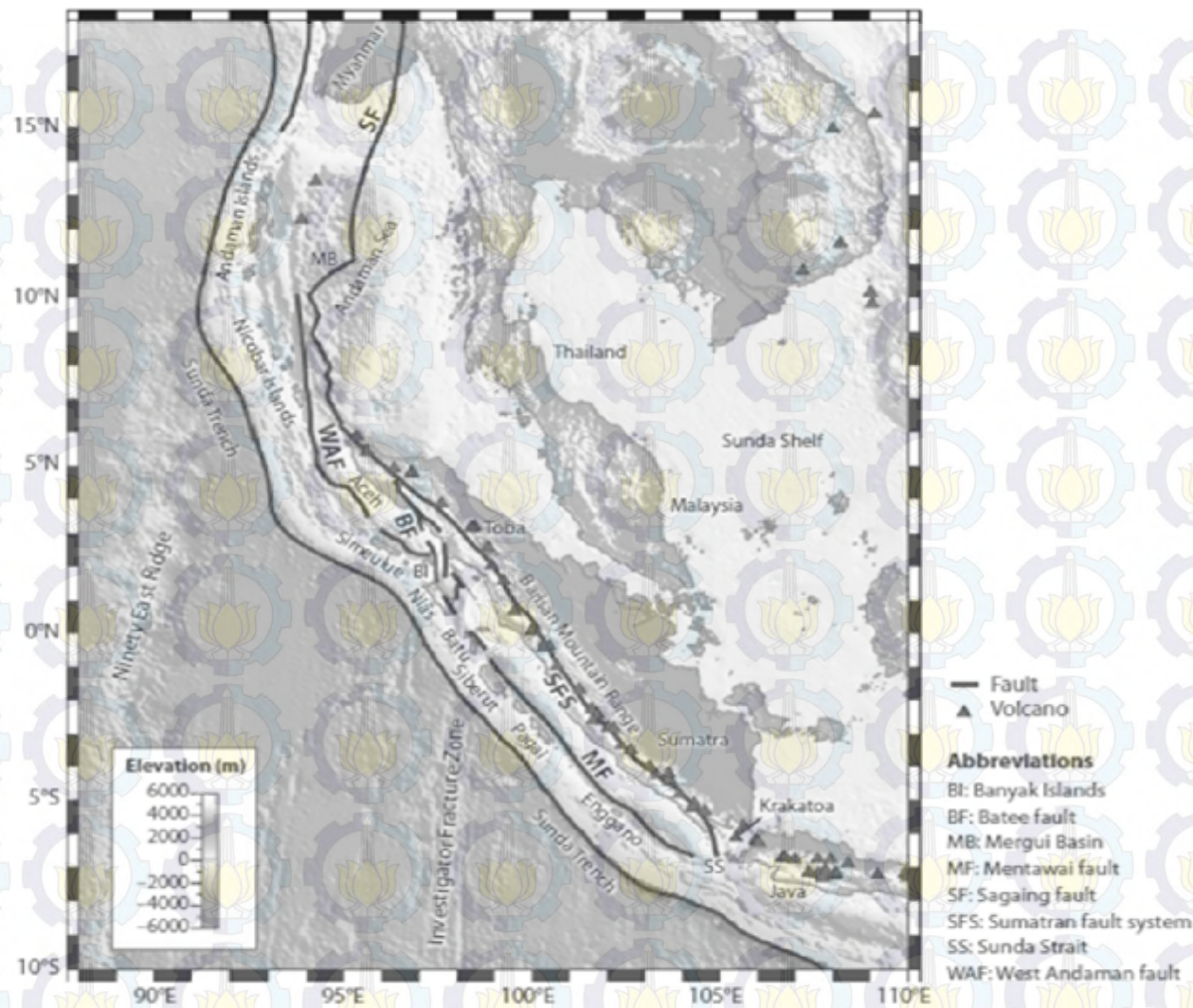
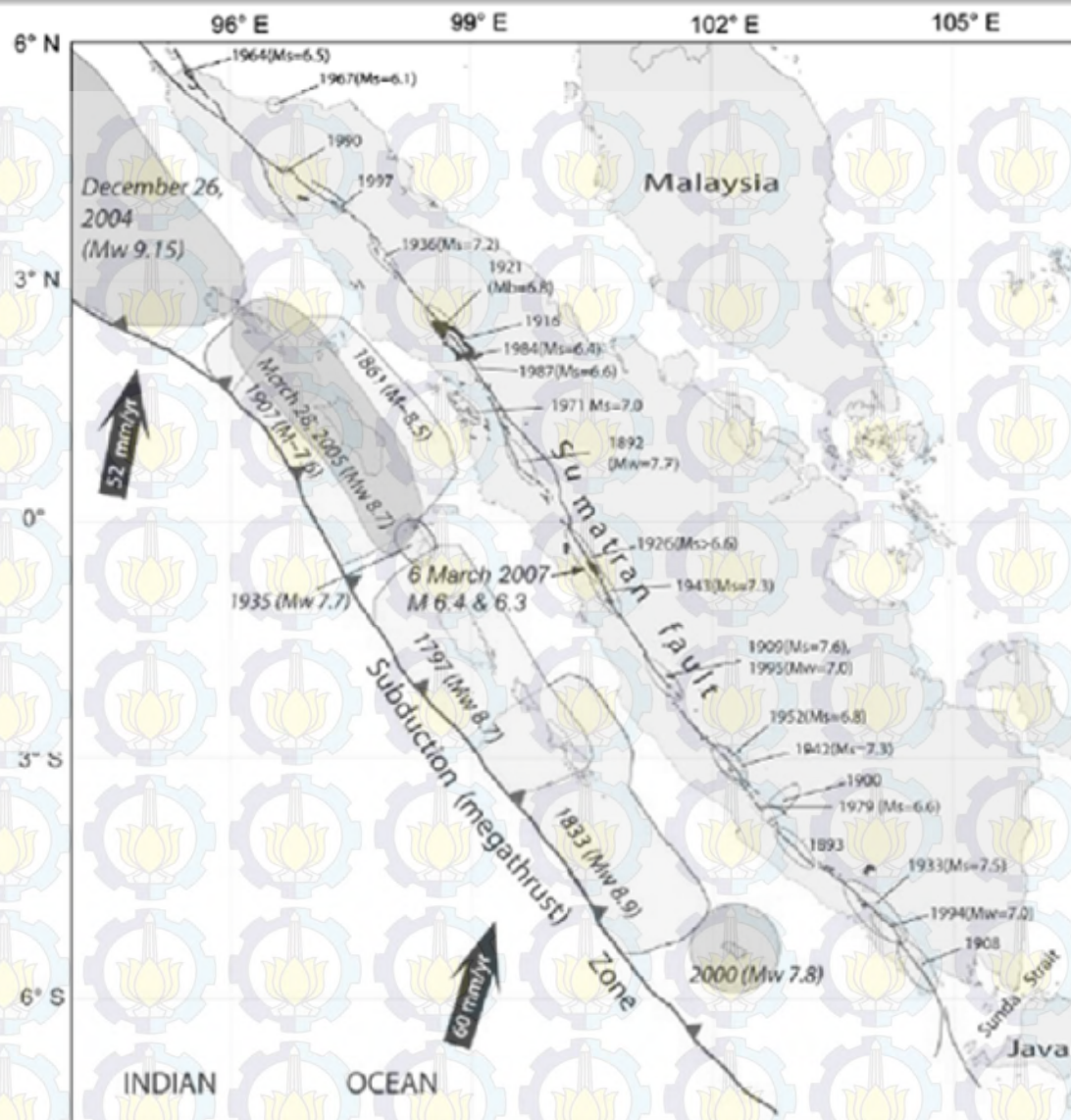


Figure 2

Physiographic map of the Sumatran region. The triangles are locations of active volcanoes. The thick red lines are faults. Data from the Global Volcanism Program, [www.volcano.si.edu](http://www.volcano.si.edu).





Gambar III-10 Gempa-gempa historis yang pernah terjadi di wilayah Sumatera  
(Natawidjaja dkk., 2007)

BACK



## Penelitian terdahulu

- Puspito et al (1993): struktur Vp 3D wilayah Indonesia dengan metode ARTB, optimasi Bayesian
- Widiyantoro dan Van der Hilts (1997): struktur mantel bumi indonesia dengan tomografi tinggi
- Widiyantoro dan Puspito (1998): Penunjaman di bawah sumatera memiliki slab yang terputus
- Pesicek et al (2008): subduksi slab di sumatera
- Caffrey (2009): tatanan tektonik & zona subduksi di sumatera
- Handayani (2012): segmentasi tektonik aktif pulau sumatera



## Penelitian Vp & Vs di Sumatera

Ardianti (2012), studi spesifik Vp Vs Sumatera Barat

Parameter	Nilai rata-rata	Kedalaman
Vp in Conrad	6.120-6.987 km/s	19.650 km
Vs in Conrad	3.535-4.007 km/s	19.650 km
Vp in Moho	6.987-4.787 km/s	45.030 km
Vs in Moho	4.007-4.737 km/s	45.030 km
Vp/Vs	1.375 km/s	

Sudiyanto (2014), studi spesifik Vp Vs Bengkulu

Parameter	Nilai rata-rata
Vp sebelah utara Gunung Dempo	Sekitar 7.35 km/s
Vp sebelah utara gunung Bukit Daun	Sekitar 7.71 km/s
Vs sebelah utara Gunung Dempo	Sekitar 4.19 km/s
Vs sebelah utara gunung Bukit Daun	Sekitar 4.28 km/s



## Contoh kelurusan seismogram

